Journal of Ocean, Mechanical and Aerospace
-Science and Engineering-, Vol.57

July 30, 2018

Effects of Electrode Velocity Variations and Selection of Electric Current Against Quality Welding Results Mild Steel on SMAW Welding

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Paper History

Received: 12-October-2017
Received in revised form: 10-July-2018
Accepted: 30-July-2018

ABSTRACT

One of the welding technology is SMAW (Shielded Metal Arc Welding) has its own advantages, such as, the current as the heat source used can be varied, easy to be used in various welding positions, penetration and the electrode width of welding can be adjusted. In order for proper welding speed, this research uses SMAW welding machine with sliding adaptive vertical system that varies the flow and welding speed to the welding characteristics, by doing visual observation and mechanical properties using tensile test. The welding speed is controlled using arduinouno with stepper motor rotation as the driving force. The material used is mild steel which has been tested for its composition content, the groove used is single V groove with 60 ° and electrode used is E6013 electrode. The number of specimens varied by 9 specimens with the highest tensile strength is 543,48 MPa and the lowest value is 253,75 MPa. Micro welding structure is determined by many factors including heat input, current strength, welding speed, and cooling rate. In this study the HAZ area has a larger grain structure than base metal and weld metal.

KEY WORDS: *Welding,SMAW,Tensteel Strengh.HAZ*

NOMENCLATURE

σ	Tensile strength(MPa)
F	Maximum load (N)
A_o	Initial cross-sectional area (mm^2)
ε	Strain(%)
l	Elongation (mm)
lo	Initial length (mm)
E	Modulus of elasticity(N/mm^2)

1.0 INTRODUCTION

The use of metal in every field of construction and manufacturing industry has increased in accordance with technological developments in meeting human needs. The development of advanced industrial technology can not be separated from the welding process because the welding process has an important role in the field of metal engineering and repairs (Huda, S. dan Waluyo, J. 2013).

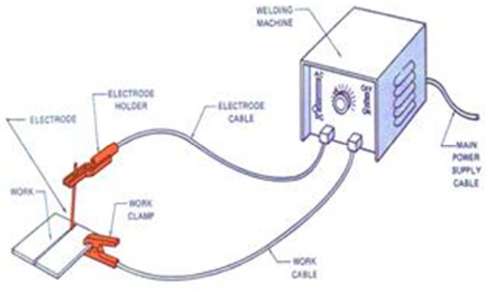

Figure 1: SMAW (Shielded Metal Arc Welding) (Kumar dan Duhan, R. 2016)

 JOMAse | Received: 12-October-2017 | Accepted: 30 September 2018 | [(59)1: 12-16]
Published by International Society of Ocean, Mechanical and Aerospace Scientists and Engineers, www.isomase.org., ISSN: 2354-7065 & e-ISSN: 2527-6085

The definition of welding according to Jenney, C. L. and O'Brien A. (2001) is the process of grafting the material by heating it up to reach the welding temperature, with or using pressure or without using a fill metal.

According to Santoso, T. B., Solichin and Tri, Hutomo, P. (2015) for industries involving metal or steel, especially in the field of development by using welding, various researches are required in order to achieve high quality welding, as it concerns safety and usage life. In SMAW welding process variables that determine the quality of the welding results are on the selection of materials plus the corresponding, the selection of current used on the engine shall be adjusted to allow the melting of the added material (electrode) to be perfect, as well as the position and welding speed to be precise. The selection of these variables depends on the skill of the operator performing them, so the determination of those variables often changes especially in terms of flow selection and welding speed.

To get quality good SMAW welding results required a trained welder, will be faster and welding position of each welder is different, so to get the constancy of the speed and position of welding has difficulty. Unlike the welding process is done using SMAW welding machine with sliding adaptive vertical system to replace the welder so that the parameters of speed and position of welding can be obtained constantly (fixed).

In addition to the positioning parameters and welding speeds performed by the operator and contained in the SMAW welding machine affecting the quality of the weld is the current used. It is therefore necessary to study and study the correlation between the current and the speed of welding to obtain a good quality of SMAW welding. The study was conducted using a material of low carbon steel (mild steel).

According to Wiryosumarto, H. (2000) carbon steel consists of iron and carbon. Carbon is an effective and inexpensive hardener. Therefore, in general most of the steel contains only carbon with a few other alloying elements. The difference in the percentage of carbon content in the steel alloy mixture becomes one of the steel classifications which are based on carbon content, low carbon steel, low carbon steel, low carbon steel.

During welding, the welded metal and heat affected zone (HAZ) will undergo a series of thermal cycles, ie heating to maximum temperature and then cooling. The thermal cycle affects the microstructure of the weld metal and HAZ, in which the weld metal will undergo a series of phase transformations during the cooling process, i.e. from the molten weld metal to Ferrite-δ then γ (Austenite) and finally to α (Ferrit). In general the time (cooling time) between the temperatures of 8000C - 5000C is used as a reference in carbon steel welding, because at that temperature interval there is a phase transformation from Austenite (γ) to Ferrite or Bainite depending on its cooling speed. Setiawan, A. and Asra, Y. W. (2006)

2.0 METHODOLOGY

This research was conducted to determine the optimization of SMAW welding machine with sliding adaptive vertical system by varying the current and welding speed to the mechanical properties of the material using tensile test. The speed of welding using stepper motor rotation with arduino uno controller.

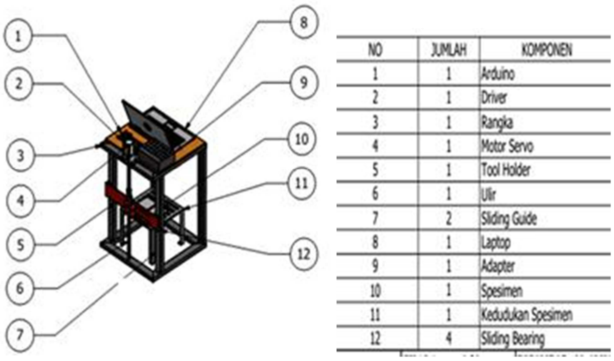

Figure 2: The concept of sliding adaptive vertical engine

2.1 Equipment

The equipment used in this research is SMAW welding machine with Adaptive Vertical Sliding System, Liquid Penetrant, Frais and Computer Servo Control Material Testing Mechine. Materials used are low carbon steel (mild steel).

2.2 Manufacture of Test Objects

Prepare test specimens according to planned dimensions beginning with literature study and preparation of the SMAW testing machine in accordance with standard operating procedure (SOP).

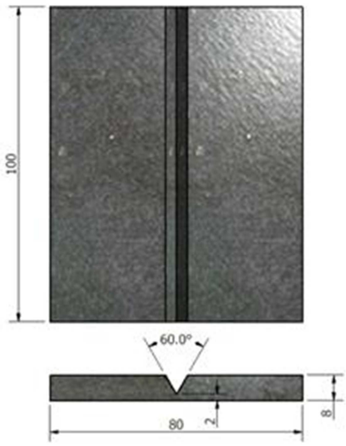

Figure 3 : Specimen welding test

2.3 Data Retrieval

In this research the data retrieval method is done experimentally, which is namely varying the current and speed of welding (welding speed) by using electrode E6013. Electrodes with code E6013 for each letter and each number have their respective meanings:

E = Electrodes for electric arc welding.
60 = Declare the voltage value Drag minimum yield welding multiplied by 1000 Psi.
1 = State the position of welding, 1 means can be used for welding of all positions.
3 = Electrodes with a shallow penetration of the material of potassium rough powder with AC or DC current.

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Table 1: Variation of current to welding speed

Specimen	Current (A)	Welding Speed Rpm
X_1	70	1,5
X_2	70	1,75
X_3	70	2.0
Y_1	75	1,5
Y_2	75	1,75
Y_3	75	2.0
Z_1	80	1,5
Z_2	80	1,75
Z_3	80	2.0

3.0RESULT AND DISCUSSION

3.1 Visual Test Results

Visual Test is a test that is nailed to the weld results by looking at and observing the weld results are visible. In this study the test is done visually to know the width of the welding results.

Table 2: Visual test result

specimen	Ampere (A)	Angle (e)°	Motor rotation (Rpm)	Width of welding 1	2	3	Average (mm)
X_1	70	70	1,5	12	13	13	12,7
X_2	70	70	1,75	10	10	11	10,3
X_3	70	70	2	10	10	10	10,0
Y_1	75	70	1,5	14	14	14	14,0
Y_2	75	70	1,75	12	13	14	13,0
Y_3	75	70	2	12	12	14	12,7
Z_1	80	70	1,5	17	17	16	16,7
Z_2	80	70	1,75	15	15	16	15,3
Z_3	80	70	2	15	15	14	14,7
Width of the average weld result							13,3

The width of welding with the highest value of 16.7 mm occurred on specimen Z1 and welding width with the lowest value of 10 mm occurred on specimen X3. From table 2 we can see the average weld width of 13.3 mm. X1, Y2 and Z3 are specimens close to the width of the welding of 13.3 mm.

3.2 Results of Liquid Penetrant Testing

After conducting nine experiments, the selection is done using liquid penetrant to find the best of the variations that have been done.

(a) The specimen welds (b) Results of liquid
Figure 4 : Penetrant Testing

Results of liquid penetrant testing sorted to do further testing. Tensile test specimens shall be done to the best three out of nine variations of which have been carried out. In Figure 4 can be seen the results of testing liquid penetrant and chooses spesiman testing will be done next, where specimens X1, Y2 and Z3 have the least welding defects.

3.3 Tensile Testing

Tensile was tested in this study using JIS Z 2201 No.7. Tensile test using Computer Servo Control Material Testing Mechine conducted in Laboratory of Quality Control, Polytechnic of Kampar, Bangkinang -Kampar.

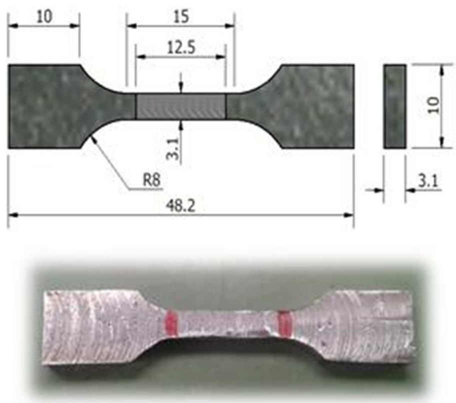

Figure 5: Tensile test specimen JIS Z 2201 No. 7

The strength of a material can be seen from the value of its tensile strength, the higher its tensile strength then the material is stronger. After doing the nine experiments, the selection is done using liquid penetrant to find the best of the variations that have been done. test and know the result of tensile test, it can be determined tensile strength (σ), Renggangan (ε) and elastic modulus (E) with the formula:

- Tensile strength(MPa)

$$\sigma = \frac{F}{A_o} \quad (1)$$

- Strain(%)

$$\varepsilon = \frac{(l-l_o)}{l_o} x\ \% \quad (2)$$

- Modulus of elasticity(N/mm^2)

$$E = \frac{\sigma}{\varepsilon} \quad (3)$$

Table 3: The results of tensile test

Specimen	Max. Force (F) (N)	Yield Strength (E) (N/mm^2)	Tensile Strength (σ) (MPa)	Strain (ε) (%)
X_1	3.126,20	117,87	253,75	2,041
Y_2	6.815,20	400,54	543,48	5,600
Z_3	7.636,00	316,46	499,09	5,208
Mild Steel	7.251,90	288,52	489,33	11,373

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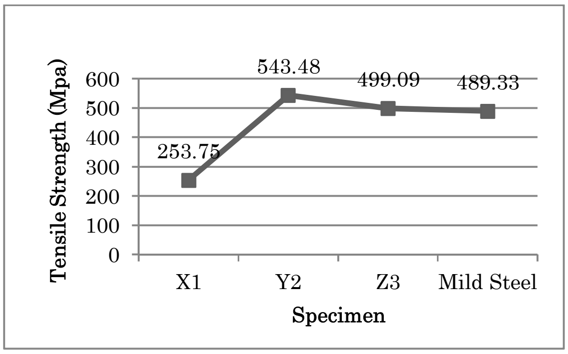

Figure 6: Tensile test result chart (TensileStrength)

From figure 6 can be seen the highest tensile strength value occurs on specimen Y2 of 543,48 MPa. And the lowest value occurs on X1 specimens of 253,75 MPa.

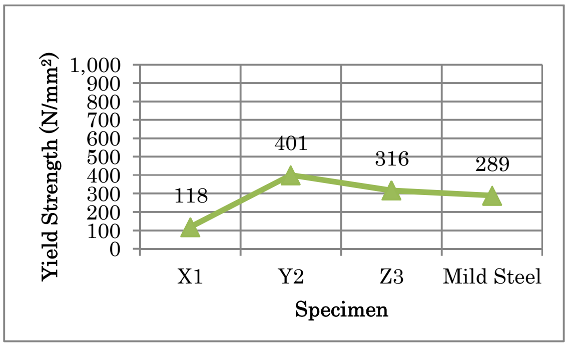

Figure 7: Tensile test result chart (YieldStrength)

From figure 7 it can be seen that the highest yield strength value occurs on Y2 specimen which is 401 N / mm^2. And the lowest value occurred on X1 specimens of 118 N / mm^2.

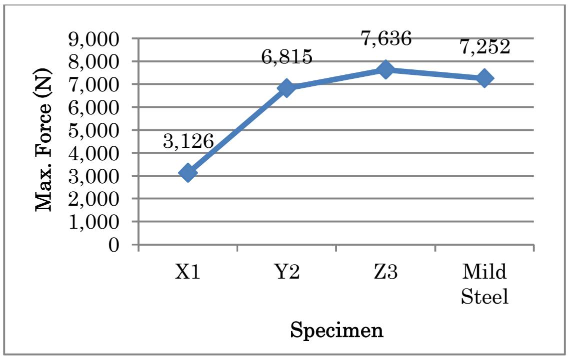

Figure 8: Tensile test result chart (Max. Force)

From figure 7 it can be seen that the Y2 specimen which is 401 N/mm^2. And the lowest value happens on X1 specimens of 118 N/mm2.

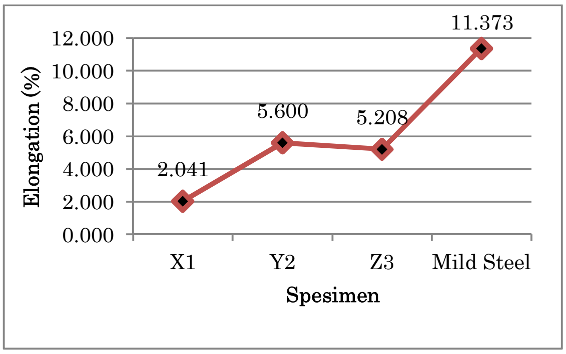

Figure 9: Tensile test result chart (Elongation)

From figure 9 can be seen the highest yield strength value occurs in mild steel specimens that is equal to 11.373%. And the lowest value occurred in X1 specimens by 2.041%.

3.4 Metalografy Test

In this study, microstructure observation aims to find out the shape, arrangement, and grain size in the weld and HAZ areas. Micro welding structure is determined by many factors including heat input, current strength, welding speed, and cooling rate.

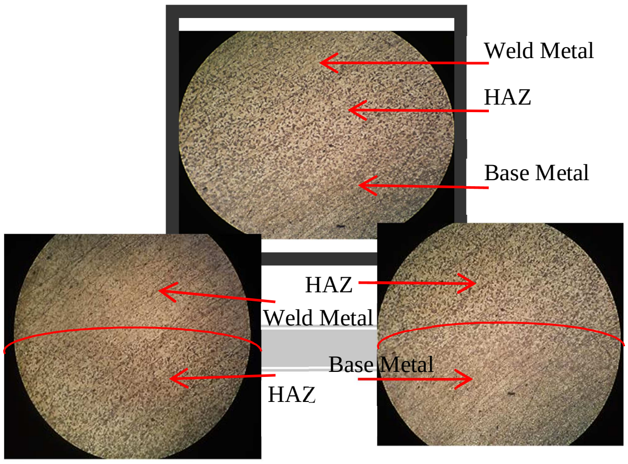

Figure 10: Metalografy results

From figure 10 we can see the comparison of grain structure dimension, where in HAZ area has larger grain structure than base metal and weld metal. Grain structure on weld metal is smaller than base metal. Based on the analysis, it can be concluded the weld metal material is stronger than the base metal material.

4.0 CONCLUSION

Experimental studies were conducted by varying the flow and welding speed against mild steel materials with a total of 9 specimens. These 9 specimens were then subjected to visual testing, liquid penetrant testing and tensile testing. Hasli of the

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Published by International Society of Ocean, Mechanical and Aerospace Scientists and Engineers, www.isomase.org., ISSN: 2354-7065 & e-ISSN: 2527-6085

test can be summarized as follows:

- By visual testing of 9 specimens the average welded width was 13.3 mm, the highest welding width of 16.7 mm occurred on specimen Z1 and the lowest welding width of 10 mm occurred on specimen X3.
- Liquid penetrant testing was performed on 9 specimens, of which 3 had the fewest weld defects, the specimens X1, Y2 and Z3.
- The highest tensile strength occurs on Y2 specimens of 543.48 MPa, the lowest value occurring in X1 specimens of 253,75 MPa and mild steel without welding specimens having a tensile strength of 489.33. In this case the tensile strength after welding is better than the strength of the material without welding.
- HAZ areas have larger grain structures than base metal and weld metal. Grain structure on weld metal is smaller than base metal

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JOMAse | Received: 12-October-2017 | Accepted: 30 September 2018 | [(59)1: 12-16]
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